METHODS AND PROBLEMS OF FACTORY CONTROL.

Paper presented to the Institution, Yorkshire Section, by Raymond J. Mitchell, M.I.P.E.

I MUST ask your indulgence for disappointing some of my hearers in that this contribution to our proceedings will be less technically detailed than is usual from our writers of papers. The original title of this paper was put up for auction, so to speak, at one of our committee meetings and there were no bidders ! Finally I was persuaded—by soft words, I fear—to undertake a responsibility which to discharge fully would occupy many meetings and we all should reach the point of exhaustion long before that could be said of our subject for discussion to-night, as originally announced.

These are days of anxiety and care for everyone engaged in productive industry, but most particularly for those who carry the burdens of administrative and managerial responsibility incidental to the operation of a competitive manufacturing business. Enormous internal taxation coupled with reduced internal purchasing power, complicated by fierce competition on the home sales front and what often amounts to a closed door by overseas one-time customers make it imperative that every device and expedient available shall be applied to ensure that what is made shall be saleable at least within the confines of the restricted market now available.

To ensure this outcome either the manufacturer is obliged to sell at the barest margin of profit—and sometimes for a time at a net loss—or he must know how and be able to apply the most rigorous control of production cost to his output without sacrifice to the quality—under all headings—which is increasingly the measure of whether his customers will continue to buy from him. From this preamble it is obvious that the chances of an ill equipped establishment muddling through to prosperity in some dim and vaguely hoped for time were never so slight as they are to-day, and such chances are likely indeed to become slenderer as industry gets under way again to full speed.

It is stated that during the last two years about 1,500 new factories have been started in Great Britain and that in the first six

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months of 1933 over £40,000,000 was expended in this country on new manufacturing plants.

Since the 1930 Census of Production shows that there were 590 factories employing 500 or over in engineering or metal industries in Great Britain and these constitute only 9.16 per cent. of the establishments included in the census it is obvious that the scope for the applications of scientific method in industry generally is mainly amongst the smaller units. Of the total of 11.38 million workers included in the census 1.86 millions are engaged in engineering or metal industries—that is 16.33 of the total, whilst 3.7 millions are employed in occupations of an auxiliary nature described as commerce, including transport and distribution—a percentage of 32.5 of the total. That is, twice as many people are doing non-productive jobs as are engaged on actual manufacture.

The remarks that follow will therefore be confined to suggestions applicable to the control and operation of establishments employing not fewer than 200 and not more than 500 people in all—a region of production wherein the problems of efficiency, as distinct from the wherewithal to meet them, are at a maximum of difficulty to solve economically yet decisively. Even fifteen years ago an analysis of over two hundred engineering firms revealed that the *average* dividend of these representative concerns did not exceed five per cent. for the period immediately following the war. Clearly then with all that has happened since it is no easy path which confronts the works manager of these days ; and more particularly when the plant under his charge is not fully loaded or may be struggling to compete with other plants of more modern character and higher or better quality output.

We will therefore consider some problems common to any small works within the foregoing definition. To make the matter more concrete we will assume that a new works manager has just arrived on the scene and has received general instruction from the chairman of the Board, who is not an engineer and not a sales promoter either, but has a shrewd idea of money, as many chairmen have.

As the querists in the etiquette columns would say, " What should the W.M. do ? " The answer is, of course, that right at first he should do nothing—that is until he has walked around the works, met all the staff, noticed whether everyone is busy (not forgetting to note those who are not), taken special interest in the dispatch department (how much went out last week), and finally found out for himself what sort of crowd has become at his disposal, what people are doing what and how, and what facilities exist for the doing, both in organisation and plant. In his preliminary tour our W.M. will pick out one or two people in particular for their alertness —there are always a few in a works who can be so discerned. Lucky for them, luckier still for our new W.M. ; these are the people who

will help the W.M. to bring the establishment into line with meeting the essential conditions of operation which are discussed in the remainder of this paper.

The Works Manager.

Much has been written about the essential qualifications of the works manager. Judged by the definitions of some authorities this gentleman must be an unearthly multiplex personality wherein are compounded a professor's knowledge of engineering, a Rockfeller's flair for finance, a Kitchener's passion for organisation, and withal a personality so compelling that thunder rumbles when he frowns, whilst his smile sends buyers rushing to acquire a further holding of his company's shares. In reality the good works manager is an ordinary human man—human and a man, these are the two essentials, since they connote the possession of those indispensable personal qualities of patience, tolerance, leadership, big-mindedness, and general levelness of character without which no works manager will reach the summit of achievement which should be his. The good works manager doesn't even pretend to know the whole body of works knowledge, but he knows to a shade just how much each member of his staff knows of that which he should know. And just as important! The good works manager knows that there will be many occasions when to reach a decision he must become a committee of one who knows very precisely what he wants and has the power to get it. This sort of works manager is by no means universal, but when a concern is lucky enough to own one it may do that concern no harm in the long run to give such a man a chance of owning at least a part of itself: and such happens quite frequently.

The Works Product.

In books on works practice one finds an airy assumption that a solid spate of orders must be executed and no work on the subject which the writer knows deals with the subjects of either too few orders, or—what may sometimes be very embarrassing—too many orders, or orders which tip the manufacturing plant right out of balance. In real life we find that practically never is there just the right quantity and kind and distribution of orders, and hence it becomes of great importance to use any endeavours which can be applied towards ensuring a tendency which shall become more pronounced as time passes for the right kind of orders to be offered.

This happy outcome can best be secured by the works manager making it an integral part of his day's routine to scrutinise most critically not only every incoming order which differs from what may be termed the average, but in addition to give equally close oversight to every inquiry which involves either special delivery

offers or technical consideration in regard to method of production, quality, design, or the like.

In two highly successful concerns known to the writer this procedure is carried a stage further by inviting the advice and comments of the laboratory and inspection staff in such instances. By keeping a special card file under each firm's name showing particular items—both technical and idiosyncratic—which require notice and attention, much possibility of unintentionally causing annoyance through some slight discrepancy in specification has been prevented.

A reputation for steady accuracy and alertness in small matters is valuable to any business, and counts heavily in favour of the firm so reputed when competition becomes intense, and purchasing departments begin to waver in former fidelities. Most small works tend to be far too versatile, which is often why they either do not grow or grow less and die.

The British engineer manufacturer is still far too prone to use the pioneering spirit in regard to this matter of diversity of product. No one can use his influence with more useful effect to counteract this uncommercial outlook better than a clear-minded works manager. Every works worthy of the name is suited for a certain class of output above all others and, moreover, has staff possessing special knowledge of such special activities. If such be not the case the concern must bestir itself with a vengeance and make itself a specialist in something or it will sink to the status of a jobbing shop in which the hope of profitable production is small indeed.

This doesn't mean that policy should be so cast-iron as to be inaccessible to new developments, but it does mean that a works which has made a satisfactory outcome of making, say, gas-engines, should not try to build electric refrigerators in the same shops and utilising only the knowledge of the existing staff. Whereas there would be no harm, and probably much justification for this works embarking on the manufacture of Diesel engines, providing its existing product was a high grade one and commanding its share of the market of engine users. Broadly stated, it seems good policy to develop on lines of natural evolution. By these means progress and continuity are assured in an unbroken sequence. If you have a reputation for dairy machinery it is unwise to adventure into motor car engine making, and likewise the buying public takes a lot of persuading to purchase a universal milling machine from a firm previously specialising in high production wood-working machines. Yet this kind of mistake in production policy has lost vast sums of capital since 1918 and is still apparent in some quarters where more judgment might have been expected.

The Drawing Office and Designs Department.

Dealing further with the product in regard to policy it may safely be claimed that at no point can the works manager impact his authority so effectively as he can in regard to design—always providing his knowledge is equal to this exacting task. The almost fatal facility with which a few lines on paper have been known to hurl a firm's reputation into the abyss or at least cause grave financial losses should serve to remind us that the designs office whose efforts do not require very close oversight by some officer whose mind comes fresh to the task must be few indeed. This is particularly true of designs which must of necessity be thought out under high pressure and produced in a workshop form within a period too limited to permit of a thorough exploration of alternatives. In such oversight the co-operation of the foreman and superintendent or of the general foreman will often be invaluable.

Whilst the works manager's outlook will be partly a customers' outlook, and partly an outlook concerned with obtaining the most satisfactory functioning of the completed machine or unit, he can and should join issue with the manufacturing viewpoint which looks at a design solely with an eye to such questions as to whether the various machining operations can be carried out in a straightforward manner on existing plant, whether any unnecessarily expensive fads of the drawing office lurk in the design, and to what degree the design as a whole could be simplified without entailing any loss of functional efficiency and sales attractiveness. Mr. Ayton's paper on "Instilling Machine Shop Sense in the Drawing Office," given recently before this Institution contains a number of pertinent criticisms on this very important aspect of works supervision and control.

Whilst on this subject a word or two on draughtsmen will be relevant. We don't as a rule treat our drawing office people as they should be handled to get the best out of them. The draughtsman should spend more time in the shops than is usually the case—he thus tends to become fixed in his outlook—his mind is a picture album instead of a cinematograph film. We—I speak of engineers as a body—ought to exert ourselves energetically to develop the very fine material that often lies dormant in the drawing office. There is too much sheer drudgery in many drawing offices, resulting in a faded mental outlook and a lack of imaginativeness. It would be an excellent investment to send draughtsmen out at times to see other firms' works, to interview customers, examine new plant, look around technical exhibitions and thus enlarge both their technical and general outlook. This is not put forward for all members of drawing office staffs, but rather for consideration as applying to the more earnest type who is genuinely anxious to

attain a full measure of professional competence.

It is vital to the success of a moderate sized or small works that its drawing office staff shall be a corps d'elite—that is, that its small numerical strength shall be counterbalanced by its brain capacity. It may not be easy to bring about but it is not impossible and when accomplished forms a major link in a small firm's anchor chain.

Indispensable Functions.

In an engineering business of the size range we are considering, that is employing from 200 to 500 people in the actual operations of manufacturing, there should be in the writer's opinion three men on a status of equality—working together in the closest harmony, forming together the brain of the business. Besides the works manager there should be a sales manager and a secretary. These three should meet frequently, be consulted together by the chairman or Board (if any outside the three chief works officials) and could shoulder together—with the assistance of reasonable staff—the three primary functions of design and production, marketing, and financial guidance, or control. In case of inability to agree on some cardinal point of policy at a given moment it is usually the case that the development of events in themselves will show the correct course before it is too late to modify opinion and consequently action. This " three musketeer " idea seems to the writer to have many potentialities of success as a framework of policy direction in a medium sized concern. Such an allocation of functions amongst men who trust and respect one another cannot but develop into a very smoothly working co-operation, providing the three parties to the association are team-workers.

In the writer's opinion such an arrangement is one which is far more likely to work smoothly than the one wherein the usual managing director functions largely by interfering with a machine of organisation he imperfectly understands. It is indispensable to the smooth working of such a scheme that all three men shall be experts in their field, about the same age (within, say, seven years) and remunerated on the same scale. The chairman should in such a case possess the money sense but need not be an engineer. A solid man of affairs he should be—not necessarily a heavy shareholder, although if he has the vision necessarily associated with the proper occupation of the position it is no detriment for him to own a substantial holding.

Summing up this matter of functional control, the works manager would control all manufacturing rank and file, sales manager would direct outside staff and such office staff as dealt exclusively with the *obtaining* of orders, whilst the secretary would deal with staff salaries, wages, costs, purchasing (under requisition and advice of

the W.M.), and all matters connected with accountancy, taxation, statistics, and finance.

It is the writer's firm conviction that many medium sized works to-day are inadequately or disproportionately staffed at the top, causing a load of detail to be thrust on to the shoulders of men whose full capabilities are therefore not released because of the obsession of detail. The smaller works need the highest grade of staff and equipment which can be assembled together at one place and time : this is one of the vital ingredients of successful development and progress. One way of implementing this principle is to divide direct responsibility in such a manner as has been put forward so that in reality there are three managing directors, although that is not the title they work under. This might be described as a managerial syndicate.

A few points concerning the staffs of these three chiefs of staff are necessary. The works manager's right-hand men would be the chief draughtsman, the ratefixer, and the general foreman, and working with all three should be an understudy to the works manager who should shoulder the duties of efficiency promoter, experimental engineer, and head of the time-study section ; that is, he should keep a close oversight of the operations of the ratefixer. According to the nature of the plant the ratefixer might have one or two understudies.

The secretary's staff would comprise a first-class head bookkeeper, and an equally able cost clerk preferably one possessing the modern outlook on costing put forward by the Institute of Cost and Works Accountants. An order clerk and general correspondent with broad office experience would complete this list in essentials. All general clerical work would be under the oversight of this section.

In the sales manager's department the two chief assistants should be a man who understands something of the technique of advertising, and as many salesmen as trial and experiment prove to be remunerative. The remuneration of salesmen should be a matter of extremely careful study. No laws can be laid down excepting that the one completely unsound and immoral method of remuneration is by what is miscalled " straight commission " under which system more crooked dealing and exploitations have been committed than could be enumerated. No respectable firm ever does it—not for whole-time service. When a salesman acts as agent, that is on another and quite different footing and a commission arrangement operates often in a manner mutually fair and profitable to both parties.

Reverting to the works proper, it appears to the writer that cost-proving or checking should be under the control of the secretary's department. This subject could occupy a whole session of our syllabus and not be even then fully covered. The attitude in regard

to costs requires drastic revision. Ideally costs should, at their least effective level, be news bulletins—whilst in their most effective operation their function can be as valuable as inspired prophecy. Plainly it has been proved to be possible to know accurately beforehand what a job will cost, to follow its accumulation of costs through the shops or on particular machines, to pull up in time if the cost totals are getting out of bounds and to achieve all this by scientifically accurate application of solid knowledge based on observation, records, analysis, control, and that increment of judgment—real imagination—by which mere routine becomes management.

When one considers the remarkable feats of cost prediction which enter into an Austin car in regard to which over 6,000 parts are subjected to the most minute scrutiny and over 100,000 operations are costed *beforehand*, it seems strange that in any average works the costing done is of a negligible character and then only historical in effect—not corrective or controlling at all. A great deal can be done in a small works by tabulating time data on operations and on the cost of various standard components which enter into assemblies. But whatever the means adopted it is sure that no business can possibly hold its own without some definite and sustained attack on the costing problem.

Other functions which merit the special attention of the works manager are those of internal transport and stores control. Regarding the former it should be known that there are now available small electric trucks running on rubber tyres and able to carry half-ton loads which will run 20 miles on a factory floor at a cost of a few pence per week for electrical energy. These little machines can be driven anywhere where a hand barrow can go and cost only £75. There is no cheaper form of works transport for odd jobs than such an electric truck rightly applied and used.

The stores of many big works are a disgrace—of some small works a crime. A very expensive crime too, wherein are sunk in waste what should have been a year or two's dividends. No stores is worth the name unless every item in it is classified under a reasonably comprehensive system including such classifications as Stock Number, Name, Supplier, Min. Stock, Max. Stock, Date last bought, Value per Unit. One excellent scheme of stores sectionalisation is to employ colours identifying various areas, as for example, steel and iron in a blue section, textiles in a green, screws and bolts in a white section, and so on. If this convention is applied sensibly a good deal of disorder can be prevented by simple means. Colour identification is not used as it could be in factories. The man in charge of the stores should be a person with a very orderly mind—not, however, given to hoarding useless junk. Many stores would hold twice as much useful material if someone had the moral courage to throw out that which will never be used.

There is a tendency to assume in some quarters that the functions of the general foreman are becoming redundant. The writer's belief is that the general foreman never will be obsolete since he is the natural personal symbol of managerial authority and knowledge—that is if he is the kind of foreman herein assumed. In a medium sized works a good general foreman can by his efforts of leadership get things done by steady common sense and quiet drive which might require reams of instructions if done by more scientific methods. The works manager's office should be ever open to the general foreman of this type, for it is certain that his comings and goings will always connote something moving forward. A wise works manager will not give the general foreman a lot of clerical work, but on the contrary will take special pains to see that this worthy official is considerately treated and made to feel that he is part of the firm. Of course it is assumed that the right sort of general foreman has been appointed.

To-day is a time of very rapid change in industry and in its internal structure. But however much the detail of managerial technique may change, it still remains true that since industry is a human institution in the long run the humanities will win. The prime object of any factory is the satisfaction of human desires and needs. Hence has arisen of late years a spirit of questioning in regard to the relations of finance to industry. The man in the street alike with the owner of a producing organisation wonders how it is that with a vast means of production at hand yet there is manifestly some missing link which prevents the benefits of the production engineer's knowledge being fully available either to the manufacturer or to the public he tries to serve. This anomaly is being studied by many minds and some very hopeful lines of solution are already receiving world-wide attention.

I would like to conclude this admittedly sketchy outline of a few of the problems of controlling a small works by quoting some remarks of Oliver Sheldon taken from his book on the "Philosophy of Management." Quite frankly I believe that if these views were more widely realised many of our difficulties—even of finance—would dissolve away and open the door to the real twentieth century—the century in which production engineers show the world how to make scarcity and its ugly relation, poverty, a stupid joke dating back into dark ages.

"Looking immediately ahead, the two major forces making for change, with which the management has to deal, are labour and science. The greater the changes these forces portend, the greater the responsibility of management for the safe pilotage of the vessel. The activities of these two forces indicate most surely that the sea which has to be traversed in the years ahead will be far from placid. Labour, viewed either as an organised entity or as a heaving, throb-

bing movement of the times, is wedded to progress. Chafing at the restrictions of economic logic, it grounds its faith upon a profound moral reconstruction of society. It steps forward into the future, deeply assured that, despite the abstractions of economists, statisticians, and politicians, the days to come will witness a revision of the ethical principles of our social order. It is convinced by neither argument nor experience. It clings to its faith in a new world of justice; it thinks upon the moral plane. It trusts to progress, primarily and fundamentally, not because progress means more material advantages and a wider and higher field for human intelligence, but rather because it promises a state of society in which the principles governing the form and conduct of society shall be founded upon neither expediency nor force but upon what is morally right. Amid the whirling of divergent movements and manifold philosophies, its ultimate goal is clearly established. Its discontent is neither of mind nor of body, but of spirit. It demands a constant impulse to go forward, it resents every setback and hindrance.

"Science is similarly imbued with the forward-looking mind. It subjects every established precedent to dispassionate research. It is continually amending our methods both of manufacture and of management. It impels us to a higher and still higher standard of efficiency. It instals method in the place of chaos, laws in the place of "rule-of-thumb,' knowledge in the place of ignorance. It sifts our experience, analyses our practices, and puts to new purpose our energies. It devises machines for our manual work, new methods for our procedure in management, new forms of our organisation. It experiments, compares, tests, standardises, organises, and re-builds. It regards no standard as final, no method as ideal, no sphere as sacred. It applies its analytical process to both the things and the men of production. Without partiality, it martials facts, discovers principles, and unhesitatingly applies them. It improves quality, decreases cost, designs products, and effects economies. It holds even efficiency to be not the negative virtue of eliminating what is wasteful, but the positive virtue of building up what is the best."

Discussion.

COL. G. BRAY (President, Yorkshire Section) opened the discussion by remarking that Mr. Mitchell by his provocative paper in which none of them had entirely escaped the winged shafts, had asked for it, and he (the chairman) hoped he would get it. (Laughter).

MR. SCAIFE: I would have liked a little more time in order to clarify my impressions of the paper before opening the discussion. Although Mr. Mitchell apologises for his professed inability to deal with this subject, my opinion is that he has dealt with it in a very excellent manner. It is a subject which depends largely upon how one approaches it and upon the varying circumstances. The methods of handling a factory where 5,000 people are employed as compared with a works of 500 people are entirely different. The larger the factory, the easier it is to manage. That is my experience. One can direct from the office of a large factory from one end of a wire, and the army of subordinates is there to carry out instructions, but in a smaller works there must be more initiative and more responsibility, and incentive falls on the manager. But different types of men are necessary to manage different types of factories. From my own experience, again, it is very much more difficult to manage a small works; as the number of men employed decreases the difficulty increases. I have managed works of 2,000 and works of 20 or 30, and I have learnt by experience so gained that to get results from a smaller factory requires more initiative, more executive ability, and generally a better all-round engineering knowledge, than is necessary in a larger factory. Without speaking a long time one cannot go over all the points Mr. Mitchell has dealt with. His ideas are good, and it is a long time since I listened to a paper which has given me more food for thought. One can easily criticise a paper of this sort on the lines of it being too idealistic, and to accomplish results one has to be able to look a long way ahead. One very efficient manager said to me many years ago: "I shall not forget that we have one manager on the floor, one in the drawing office, and one directing operations." And that is the only way to make progress.

I have certainly not felt antagonistic towards the paper, but when Mr. Mitchell advocated that the works manager should take control of the designs department I do not agree for several reasons, though, of course, it depends very largely on the functions of the works manager in a particular case. There are definite cases where the draughtsman should ask for the ideas of the works manager, and there are others where the needs of the case are best known by

the chief designer. It is the ideas of the chief designer which have to be put into practice, and he designs with a particular object in view. The works manager is the man who has to make things according to specifications, and is not there to decide matters of specification themselves. The works manager is not expected to design, and if you are going to put the designer under the works manager, progress would be seriously limited. In all cases where a change is made in design they should submit the alteration to the works side with a view to getting their ideas, but the last word must be with the chief designer who is responsible to the board of directors. I have been speaking, of course, of large works where there would be a metallurgist. In small works of 200 people you could not employ a metallurgist, and the chief designer in consultation with the works manager would be the best arrangement there, though a certain limitation of progress would be met with.

MR. MITCHELL: I am obliged to say that I almost entirely agree with Mr. Scaife. In making that statement I do not admit retracting anything I put forward in my review. I was particularly discussing works of a small character engaged in many phases of engineering work. When you get into the field of aero engines, for instance, you do not find many works on the small side (though they may be small in appearance) and in that special class I certainly should not dream of permitting the interference of the works manager, I should only ask for his co-operation. In the cases I have mentioned the works manager should be big enough to have the last word and be able to shoulder that very high responsibility.

MR. SCAIFE: Would you have it so in the manufacture of automobiles or electrical machines?

MR. MITCHELL: Not completely. In examining this question more carefully one finds two ends of a scale, and the further up the scale one goes more and more one hesitates to put upon the works manager that full degree of responsibility of which I speak.

MR. SCAIFE: Quite so.

MR. HARROP questioned the soundness of the view about works managers being competent engineers, and he also raised a point about the works manager controlling the draughtsman. He gave an illustration of a little job in connection with the drop stampings which came within his experience. He said that the draughtsman decided to have it made with a stronger steel, giving several specifications of steel. The production staff had no control at all over the drawing office, and they had to do it, although they knew that the ultimate result would not be what the draughtsman expected. On the question of the low costs of some firms, it was hardly believable how low they were in some firms in the present day. At one firm when a certain job had been done a fortnight, some costs clerk or other went into the shop and asked: "How long

were you on the job? We want to know what to charge a customer." (Laughter). The same firm once did a job for his firm—two very large shafts, 2½ tons apiece of carbon steel. Both had to be scrapped and the firm had to replace them. It seemed a wretched policy, and it showed the type of management it was.

MR. MITCHELL said that as to the soundness of the view about the works manager being such a competent engineer that he could take the responsibility of vetoing the chief draughtsman's work, he held a solid conviction that unless a works manager was able to take that responsibility he might be reliable in other jobs but not as a works manager. A works manager must be a seasoned and veteran engineer with a quiet, dominating personality whereby he showed himself entitled to the last word. Being a wise sort of man he would be careful to limit his criticisms to general principles. I am not in a position to prove my arguments in the manner of Euclid; I can only speak from personal conviction. In regard to costs, Mr. Harrop's personal testimony goes towards confirming that my remarks were not too extreme.

MR. NICHOLSON proposed to ask Mr. Mitchell which he thought was the better way of dealing with works either from a functional method (where machines are together in groups of different types) or what might be termed the straight method (where a product was produced as a unit in a department where the necessary machines were all together in a complete unit)? Personally, his view was that there were many things to be said for both methods.

MR. MITCHELL: Quite frankly, I have not had a broad enough experience of large scale manufacture in mechanical engineering to hold very strong notions on this question. I have been in two establishments, however, one rather large, one very large, where in both cases they were engaged in mass production in the strict sense of the term, and in both cases the limits of accuracy were of a very high order though the products were totally different. In both cases the functional groupings of machines was evidently believed in for it was fully practised. I should have to do a great deal of thinking to give a positive "Yes" or "No," since I think it would depend on so many conditions which would have to be stated, but I can hardly imagine any set of circumstances of an embracing character being applicable to the problem. I can lay out on paper plausible ideas supporting either scheme, but on the whole the artless simplicity of doing all milling in a milling section and grinding in a grinding section seems plausible, but facts show it is not so after all.

MAJOR WATSON: It so happens that in the course of a misspent life I have occupied, at one time or other, all the various positions Mr. Mitchell has referred to, including management, designing, selling, secretary and keeper of accounts and costs. And I know

from experience that there are certain tendencies amongst all these people which have to be mutually corrected. As regards the designer, he being a poet of metal (as Mr. Mitchell so aptly put it) his natural temptation is never to do a job the same way twice, because if he does he is not showing originality. (Laughter). On the other hand the works manager is thinking about getting the job out. What he hates like poison is a change of any description and he would like to do a job in the same way from now to Kingdom Come. (More laughter). These two tendencies have to correct one another. This will not be done by making the chief draughtsman boss of the works, or the works manager boss of the drawing office. I think Mr. Mitchell and other speakers have rather overlooked another individual who comes into the argument—the general manager or managing director. My idea is that that man has got to be an autocrat—the absolute boss, and no mistake about it. It is his business to correct the natural tendencies of the people occupying the various offices in a works to minimise the value of the other fellow, and to see that they come together. It is his business to see that the views of the works as regards production are properly considered by the drawing office, and that the views of the drawing office as regards the accounts side of the business are not looked upon too scornfully by the works. In an engineering establishment the general manager or the manager of the works is best if he is a pure business man. I am not referring to a manufacturing establishment using engineering machines but an establishment actually producing engineering work. He must be an engineer who must grasp the fundamental object of the whole thing, which is to make the thing the public demands at the price the public will pay for it. That seems to me the essential function which brings everything together and with the right kind of managing director the difficulties spoken of will be met.

MR. MITCHELL said that because of Major Watson's longer experience he (Mr. Mitchell) must listen with great respect to the points he had submitted, and he did. In his paper he was particularly referring to works of two to five hundred men, and he was outlining an ideal in the way of functional control.

MAJOR WATSON: May I suggest the owner at once in that case?

MR. MITCHELL: I said he need not be an engineer, by which I meant it was not vital either way. In my experience of engineering I have found that it is astonishing how the ordinary public can grasp the essential "guts" of an engineering problem if they are explained to them in straightforward terms. The British national is instinctively an engineer in a sense, and although we may not live among engineering paraphernalia we seem to take it in quite unconsciously.

In reply to a question by Mr. Hartley, who raised the point of an

estimate being given by a proper authority and not being followed through on a rate-fixing system, MR. MITCHELL said his reply to that would be the same sort of reply as the man gave his wife when she was questioning him after his return from church. "What was the parson talking about?" she asked, and he said: "He talked about 'sin.'" "And what did he say about it?" she pursued, and the man answered: "He didn't hold with it." Mr. Mitchell went on to say that in a works operating under conditions where someone was living in dreamland believing that simple estimating was really going to cover the job on hand and no proper machinery existing for carrying it through, hardly any words would be too sarcastic to describe such a situation. He was afraid it was not an uncommon thing, however. An estimate got out, the tender submitted, the order obtained, and then everybody sits back heavily and hopes for the best—a typically English state of affairs. Admittedly the whole question of estimating is extraordinarily difficult. So much is that so that it should be the sole concern of an engineer who has a flare in that direction. In short, there do not at present exist sufficient qualified people in this country to deal with these problems. I think we ought to face up to the fact and admit it.

MR. NURRISH: Mr. Mitchell in classifying his big three in a works organisation—the works manager, the secretary, and the sales manager—puts the costs accountant under the command of the secretary, who is often a man who cannot know how the costs are made up. As the costs are a very essential part of the purview of the works manager, I consider that the works accountant should come directly under the works manager, and not under the secretary who has no means of knowing the essentials.

MR. MITCHELL: On the face of it Mr. Nurrish has me beaten, but again I remind him that the names of these three executors do not necessarily describe exactly the sort of people we meet in real life —at least not fully. These three men working together I am assuming as time goes on know a great deal indeed about each other's problems, and whilst not admitting that only an engineer can supply a reliable data, and to that extent I maintain it is likely to conduce to harmony and efficiency if the modern accountant, whom I assume to be our secretary, is the controller of the arithmetical operations by which these costs are assembled. I am quite agreeable that the actual work whereby the costs are determined in the first place—I suppose I have no alternative—devolves upon the works manager. From the standpoint of profit and loss, I certainly think that the right sort of secretary in this year of 1934 should be able to adapt himself to undertake such responsibilities.

SINGLE-PURPOSE MACHINE TOOLS FOR DIFFICULT OPERATIONS.

Paper presented to the Institution, Birmingham Graduate Section, by F. Griffiths, A.M.I.P.E.

Introduction.

ON considering this subject, after being asked if I would take it on, I had some difficulty in making a decision as to how it should be handled. I had three courses open to me ; first, to endeavour to make the lecture a sort of pleasant evening picture show ; secondly, to build a lecture purely from the designer's point of view, using illustrations, diagrams, and calculations ; or thirdly, to endeavour to give a lecture trying to put forward the approach of the planning engineer and designer to whatever special machine is required.

After considerable thought I turned down proposal number one because most of you have ample access to pictorial surveys of special process machines in the numerous engineering periodicals which are now published. Proposal number two was also rejected because I realised that the majority of the members of our Institution do not belong to the designing classes, so that my only course (and I am of the opinion that it is an excellent course) was to deal with the subject from the point of view of the approach of the planning engineer and designer to conceive and contract for the correct type of design of a special purpose machine.

Let us consider briefly the position, relationship, and inter-dependance of these two engineers, because there is no doubt that there is a distinct tendency on the part of each to cut the other out ; either the planner will not consult the designer when laying out methods of manufacture, or the designer will not consult that silly so-and-so when making his design.

This is undoubtedly wrong. If there are any two units operating under industrial organisation which should operate as one, it is these two. Their jobs, while distinct in operation, are entirely common in ultimate aim, so that every effort should be used to foster and encourage the necessary co-operation.

It seems to me that the planning engineer should make it his aim not so much to keep in touch with design as with new processes and

their application, while the designer should endeavour to keep in touch with design and capability of machines rather than new processes. A good designer can always apply his knowledge to suit any process providing he is given its limits.

One of the main arguments in support of co-operation between planning engineers and the designer is that of tool and machine operation design. This is particularly essential in relation to special purpose machines, when the design is to be carried out by an outside manufacturer. I have a strong belief on this question of outside design, which I hope to enlarge upon towards the end of my paper, but whenever it is employed it is vitally necessary that all tool machine operation and swarf clearance design shall be submitted to the design office of the using firm, for scrutiny, in order to maintain uniformity with existing practice in the shop where it is to be used. Particularly is this necessary in regard to tooling, which, although the proposed new tooling may be somewhat superior, it is not always advisable in consideration to special upkeep. There is no doubt that there is a considerable waste of money at the present time caused by planning engineers accepting special machines without the tooling being qualified by the designs office.

I myself am a great believer in the necessity of having machines operating on a section as nearly alike as possible. I think that where you have a line of machines producing various operations of a single unit, and where the variety of the machines is great owing to their being made by various manufacturers, this is entirely wrong. If your operator, who is a single operation individual, gets used to one method of machine operation, and then owing to other circumstances has to operate one of the other machines which is totally unlike his own, he is totally lost, and, incidentally, so is the output of that particular section.

Let us for instance take the crank shaft section of a motor manufacturer who has a number of different sizes of crank shafts to make. You have first of all a considerable number of special purpose machines each doing the same operation on different sizes of crank shafts. The outfit does not warrant an operation for each machine, so that you have to have each operation capable of operating a number of special operation crank shaft machines. It is quite easy to appreciate that if the operator has continually to change his system of operation of the machine, there is a decided danger of a considerable scrap or loss of section output.

I stress these points of standardisation of special machine tooling and operation, and the necessity of this close perusal by the users' designing office because I am of the opinion that reduced running costs and smoother section operation can more easily be acquired.

We will suppose that the planning engineer has a particular component to manufacture. Naturally, his first objective is to

decide the type of operation processes he proposes to use, and when a careful decision has been made he must then decide upon the type of machine he proposes to use. He has, of course, always before him the fact that practically the whole of the operations of manufacture on a given component are capable of being carried out on standard machines, and it is here that he must make his decision as to whether he will use a special purpose machine or not. This decision depends upon three points, namely, time cycle of operation, cost, and delivery time of whatever machines he proposes to use. It seems to me that the only decision that the planning engineer can definitely make is that of time cycle. The factors of cost and delivery times must necessarily always be in the hands of the designer. It is essential, therefore, in order to make an efficient decision as to whether a standard type of machine or a special purpose machine shall be used, to have complete contact between the planning engineer and designer during operation layout.

Given the time cycle and process of the operation for which the special purpose machine is to be made, what is necessary on the part of the designer to enable him to fulfil his duty? I have found that experience on unit cost on special purpose machines is an immense help. The designer must be able to rapidly picture his machines as to size, function, toolage, waste clearance (the latter is especially important when the operation is one of machining with high speed cutting metals) and possible future use and scope. It is advisable for him to have had considerable experience in costs of previously made special process machines, so that he can give his new costs, say, to within 10 per cent.—two or three days. This rough figure is very necessary to the planning engineer so that he may be able to quickly complete his work.

You may be of the opinion that it is impossible to give those figures which I have just mentioned, but I have no hesitation in stating that if the designer is kept in touch with costs of previous special machines (which is not often done) he will have no difficulty in making up his mind when he definitely has the type of process and time cycle of machines to work upon.

Of course, it may be that a price is given with the inquiry. Then the order must be somewhat reversed and the machine must be designed to a price, but in any case it is absolutely essential for the designer to know all previous costs, particularly those of unit details.

The time factor of delivery relies entirely on the designing office and its organisation and methods by which it has to prepare its drawings. There is a tendency to-day to make the designs office what I call inefficient on a costs basis in order to make the shops efficient. Immense amounts of time have to be spent in making drawings, whether twenty or one unit is to be made, absolutely fool-proof. I am doubtful as to the cost value of this over the older

method of personal instruction and sketches, especially when one unit has to be made, but the real point is the delay of delivery time of complete drawings, and I know that it is no uncommon thing for it to be ten weeks, from the placing of instructions, before the necessary complete drawings are issued. I am of the opinion that this is five or six weeks too long.

It is a subject to which an entire evening could be devoted, so that I will not labour the question too much, except to add that it necessarily affects the decision of the planning engineer as to whether he can afford to put in temporary plant, pay for the special machines, and then recover his costs with what he saves in time labour over a possible standard method.

After deciding on the particular process by which a component operation is to be made, the next important point toward decision of the design of a special purpose machine is necessarily that of the time cycle. It is a popular fallacy among designers that the shorter the time cycle they can obtain on a special machine the greater the achievement and the better suited the machine. This is not so, as many factors arise which to a large extent nullify any advantage gained.

Of course, if a machine can be designed, with little extra cost, which is capable of anything up to the limit of whatever tooling may be used, so much the better, but this must not be looked upon as the main factor. The obvious factor controlling the time cycle of a special machine is the time cycle of the line of operations in which it is to form an integral part. For instance, it is no good making second and subsequent operation machines to complete their time cycle in half the time of the first operation. This tends to cause a waste of time by the operation, and only uses the plant for half its capabilities.

The careful studying of time cycle will on numerous occasions enable the designer to save considerable costs both initially and on maintenance, by using simpler and slower operating mechanisms. Simple tool design and upkeep can also be obtained in this way. I am afraid that in order to obtain a spectacular operation on a special machine, designers as a whole will ignore this possibly very important saving. I would impress upon you the importance of taking this advantage of time cycle when designing your special machines, in that simplification of design and easy tool upkeep can be obtained.

There is one other point we might consider which affects both the planning engineer and the designer. That is, whether to adapt a standard machine, which by the removal of certain parts and the addition of others can be made quite capable of fulfilling the required function, or design an entirely new machine. I have, as a whole, considerable objection to trying to adapt a standard type of machine.

It is not always a cheaper course, as would at first appear. Renovation, time spent by the designing staff in measuring up and drawing out and the usual poor general design of standard machines, making special attachments ugly, dirty, and difficult, all act in opposition to the apparent cheapness. It is very often a cheaper proposition for the designer to start with a clean sheet of paper, than to try to fit in awkward and untidy attachments to an existing machine. There are, of course, always exceptions, but these are generally operations which are so nearly alike to a standard machine operation that they do not enter into a discussion on special purpose machines.

We have now arrived at the point where we can profitably inquire into the general structure of special purpose machines. When considering this general structure, which is the designer to choose ; unit or block construction ? Perhaps it will be advisable for me to explain to you exactly what I mean by unit or block construction.

Unit construction is the building up of a machine with each unit, such as the head, head box, cam box, saddle or bed, a separately and completely self-contained unit, which when assembled with one another, form the necessary machine.

Block construction can be taken to mean that a machine is designed as a whole with head, head box, cams, and slide mechanisms as built-in parts.

I have for many years advocated unit construction on the part of machine tool manufacturers, so that simple type machines can be bought by the users allowing for extra units being obtained as required for various adaptations ; in other words, standardised special purpose machines.

This would obviously enable a component-manufacturing firm to purchase constantly from a machine tool firm one simple type of machine for a range of operations, stocking and buying various extra units as required, but each machine tool representative of whom I have made the inquiry always considers it impossible.

To counteract this condition, I have been able recently to design a series of machines for special purposes such as crankshaft journal turning, crankshaft pin turning, crown wheel turning, flywheel turning, and so on, which are built up mainly of standardised units such as heads, head boxes, saddles, brakes, and electrical gear, which has enabled the firm by whom I am employed to produce special machines of these types extremely economically and well below the price of the outside manufacturers' of similar machines. I may add that the next move with these same units is to build up a die-turning lathe for tool-room work. This shows that, once started, this method has unlimited scope.

One of the great advantages of such unit construction is the

simplicity of bed design; it is only necessary to design this of straight-forward strong box pattern.

I am of the opinion that block design is only suitable for quantity production where the machine manufacturing machinery is extremely flexible and capable of large work. Suppose, for instance, a bed was designed somewhat after the fashion of the Potter and Johnson Auto, or the Gisholt Simplomatic, which, as you know, has all gearing and cam work built inside, and which, when stripped, looks one mass of bores. It does not require much imagination to appreciate that the boring alone is a long winded affair, requiring large capacity machines for long periods to produce.

On the other hand, unit design simplifies manufacture, and much smaller manufacturing machine capacity is required, besides the capacity of spreading the units over a larger number of manufacturing machines. Again, unit manufacture would, if necessary, enable the work of machining and building to be spread over a number of outside firms with a great saving of delivery time. True, there is the extra cost, under unit construction, of joint faces and screws, but I am of the opinion that this is cost well covered.

A further advantage of unit design is one which is unfortunately not considered enough. I refer to convenience of repair. There is nothing generally more annoying, more costly, needing longer break-down times, than a block constructed machine. A unit can be removed easily, taken to the repair department, put in order, re-bored, re-bushed, etc., with ease, but in block design, with the awkward removal of effective parts of the machine, no re-machining is possible without complete removal.

There is also a great advantage to be gained by standardisation of units. Those machines which I have mentioned as having designed, were all built up of standard units which, after designing the first one, enabled me to give a design delivery time on subsequent machines of four weeks or so.

I think then that there is no doubt that for both the planning and designing staff, the principle of unit construction is a point well worth insisting upon.

Whether to design your special machine mainly of welded or casted structure depends on a number of points. There is the question of the facilities available for welding to be considered. If these are large and experienced, a fabricated structure can be quite cheap, but if elaborate drawing office work is required, cheapness and delivery time can be easily jeopardised. If the welding department can cut out the plates without much machining from an assembly drawing of the main unit, I can conceive both a

cheap and quick job being produced, but if each plate has to be drawn out, then the time spent by the designs staff will increase both cost and delivery time.

Again, if more than one machine is required, the costing method is extremely cheap, as the pattern cost, which is the main cost, decreases proportionately with the increase of the number of castings required. Also, should another machine be required at a later date, the patterns are readily available for immediate castings. Of course, should the structure be required to be of particular strength (not rigidity, which is totally different) another viewpoint arises, and no doubt fabrication can be substantially used. As far as appearance goes, I do not think there is much in it, as a fabricated machine can be made to look quite as pleasing as a cast one.

Summing up on fabricated or cast structre, I think we may say that if more than one machine is required, the cast method is both cheaper and quicker, but should one only be made, then, providing the welding department does not require too much detail from the D.O., the fabricated structure would be economically sound.

Passing on to discuss electrical or mechanical operation, we have a point of view which has as yet been undeveloped by the manufacturers of the smaller types of machine tools. The makers of the heavier type of machine tools have been forced by the necessary speed of operation now required to completely electrify their machines, and it is a delight to see some of the operating control being used. Amongst the smaller machine manufacturers particularly in England, experiments are still being carried out with the complicated and costly mechanical, electrical, elanic and pneumatic systems. Why this is so, I fail to appreciate. I cannot understand why any machine should use more than the first two, at the most.

I think that one of the first considerations in this matter of control, is energy output by the operator. For instance, if your special machine has an operation to perform which requires a constantly high degree of accuracy, it is obviously necessary to reserve the operator's energy by giving as little machine operating output of energy as possible, so that he will be able to retain his accuracy of work to the end of his working period. All mechanical means of machine operation require energy output much more so than electrical, where it only means pressing this or that button.

A further advantage is obtained electrically by remote control, which, instead of shafts and awkwardly placed handles, consists of just a few wires with push buttons immediately in the vicinity of the operator. I have seen modern machines where, in order to obtain drive and operation of clutches, shafts, gears, and rods have had to be taken half-way round the machine, causing not only

awkward manipulation, but considerable output of energy through friction.

Again, the peak of operation electrically is absolutely instantaneous, whereas mechanical operation is slow and nearly always means the use of springs. Even oil and air are slothful when compared with electricity.

There is no excuse to-day for the designer not using electrical control, as the firms, even in this country, who manufacture the necessary appliances, have made rapid advances in design and decreased costs.

We have still another important point on this subject which is well worth considering from the designer's and delivery point of view. It is that of cost, and spread-over of design time. I have found that it is much quicker when considering the general and detail design of a special machine, to make the decisions for electrical rather than mechanical control, for once the general plan has been decided upon, the designer can wipe his hands, so to speak, of that side of the question, which can be passed over to the electrical equipment manufacturer, who will proceed with the necessary work immediately.

On the other hand, with mechanical control, the designer has to proceed with the designing and detailing which will automatically increase the general designing time of the whole job. I consider that 25 per cent. to 30 per cent. of designing time can be easily saved by this means. I am also of the opinion that on a cost basis, including design costs, electrical control is considerably cheaper than mechanical control.

This question of control brings up the necessity of intelligent positioning of whatever control stations or handles are required. The designer, when designing special purpose machines (and for that matter, standard machines) should always see to it that these stations are in such a position that the operator has only the smallest amount of movement to make contact, and so that his hands can find the stations without necessarily removing his eyes from his work. Electrical control is particularly valuable here, especially when nothing is required for tool setting or for component loading.

There is one point in both special machine and standard machine design that seems to be singularly neglected by the majority of designers. That is, swarf clearance and coolant supply. I would suggest that if you took a stroll round any machine shop, you would find that 95 per cent. of the machines had hopelessly poor methods for both these. I suspect that it is a case of accepted practice.

It is necessary for both the designer and planning engineer to carefully study this, as there is nothing that causes so much annoyance to the operator. A cleanly-designed machine will always cause the operator to want it clean, which is not only good for the machine,

but for the operator himself. A dirty machine means not only bad attention and lubrication, but possible poisoning to the operator.

I am also of the opinion that a good coat of paint facilitates cleanliness, but I know there are some engineers who consider it a waste of time and money (they call it " spit and polish," I believe). Incidentally, this is rather curious, as a machine costs, we will say, £500, and the painting about £5 ; an enormous waste of cash, I am sure ! This £5 would be saved in repairs alone many times over before the machine became obsolete.

To the designer, then, I would say, design your main lines as clean and as smooth as possible ; avoid internal holes, recesses, bosses, and projections as though they were poison, as an operator will always wipe over a clean surface, whereas he soon begins to damn when he has to poke into recesses and fiddle around projections.

One further point on design is that of lubrication. Always see that, if possible, automatic oiling takes place, so that the obligation is removed from the operator.

If internal or automatic lubrication cannot be accomplished, use the one-shot, which, although ugly, is perfectly efficient and is being continually improved by the various manufacturers.

I have seen recently a modern machine (incidentally British made and designed) for crankshaft grinding, delivered within the last six weeks, which has at least 50 separate lubricating points. Some of these are bound to be neglected, with the consequent results, besides wasting considerable time each day for attention. Why one-shot was not fitted, I do not know.

Passing on to the rather larger issue, that of whether a special purpose machine should be designed and made by the user or by an outside manufacturer, we have a point of view which does not involve as a rule a decision by either the planning engineer or the designer, but by some higher and more obscure power, but I think we should do well to think out some of the points for ourselves. We will assume for convenience of our discussion that the using firm has both the plant and designing staff for carrying out the necessary work.

From the users' point of view, I am of the opinion that there is everything to be gained by the design being carried out or controlled by themselves. Standardised tooling and machine operation could be accomplished with ease, while if unit construction is used, existing designed units can be utilised with a great saving in delivery time and costs. I have known cases where designing which could have been carried out by the user, was placed outside because the users' machine and tool manufacturing plant was already overloaded. My objection to that is that if the design has been efficiently carried out, particularly as regards detailing, the actual making could be easily carried out by any machine or tool maker. From the

designer's or planning engineer's point of view, the question as to where and by whom the particular machine is to be made is of no very great importance.

Unit construction is particularly advantageous here, because if necessary, units can be made by anybody capable of making them, and then delivered to be assembled into a complete machine by the using firm.

There is on the whole a distinct advantage to be gained by the manufacture being carried out by the using firm, inasmuch as his machine-manufacturing plant, which is used for all the other variety of work which machine and tool usage and manufacture entails, has one size of overheads (and this applies also to the designing staff) which tends to make the cheaper type of machine more expensive and the expensive machine cheaper.

The outside machine designer and manufacturer as a rule gets much nearer to the true costs of a particular special machine, which in turn naturally reflects in his prices. This gives an apparent cost advantage, especially on the more accurate types, to the user who manufactures his own machine, and I suppose, considering everything, the apparent advantage does in reality become an actual advantage.

Referring to the point of the cheaper type of machine becoming more expensive, I would like to give you an example. I was requested some time ago to design a polishing machine which was to be competitive both as regards design and costs with existing outside-designed and manufactured machines. I succeeded quite well with the design, but not so well with the price, because these polishing machines, which could have been manufactured quite easily with a simple plant composed of simple lathes, plain millers, sensitive drills and a small planer, had to be made with a plant which included in its overheads much more expensive machines and methods of manufacture.

On the other hand, when designing much more accurate special purpose machines, such as borers and crankshaft lathes, etc., the reverse is always true. The same applies to tools, and I have often wondered if it would not be advantageous for such a user to have two distinct plants for these purposes.

I have as the last point that of rough methods of estimating costs, but, on trying to analyse my own rough methods I found that I would find it very difficult to lay them out categorically. I will, however, endeavour to give you a very brief outline.

Of course, it is vitally necessary that previous experience in the design and costs of special machines shall have been acquired. One must, for instance, be able to estimate the rough weight. I always take the weight and estimate the material costs first, and as the price of mild steel and cast iron, which are by far the greater portion

of any machine, are about the same, I fix a common current price between them. This will give me a rough material cost of my machine, and I have found that my labour costs are, with the very simple machine like a polishing lathe, about equal to the material costs, but with the very complicated and accurate machine like gear-running-in machines, the labour costs will be about three times the material costs. Experience will have to give the proportions that lie between these two. Units such as motors, electrical gear, pumps, etc., are estimated separately, and those three costs totalled up will give the actual cost without overheads.

There are, in addition, certain costs which should be included alongside the actual cost of a machine when making the decision as to whether a special-purpose or standard machine shall be used. These are, cost of temporary equipment, and the cost of the difference between the time the component is actually produced under the temporary method and the time it will be produced under the special machine. This last cost, of course, will increase proportionately with the delay of delivery time, so that you will readily appreciate why, during this paper, I have stressed the question of delivery time.

I have a suspicion that this delivery time cost is not as a rule included when estimating special-purpose machine cost, for if it were it would probably be found that a larger price could be paid in order to bring delivery forward a considerable period.

UNUSUAL PRODUCTION PROCESSES.

Discussion, Birmingham Section, opened by G. H. Wray.

THERE can be no progress in any phase of life, whether it be art, science, or engineering, if we continue to do things in the usual way. Conversely, all progress is made by men and women who look at the problems of life and say "Isn't there a different way—a better way?" On this path travels the genius, the inventor, the reformer.

Only about a fortnight ago one of my colleagues had to design a piece of apparatus, of which we have many in our works, and many in this country. He looked at it and found a fundamental fault, re-designed it, and the cost of it will only be about half of the standard article. I do not want to tell you what it is because we have not yet tried it out, but I am convinced that it will work.

This meeting of production engineers has been called to remind ourselves that the usual way is not always the best way; that although we rightly use our past experience in the solution of a problem, we must continually be finding a better way, however unusual it may be.

In opening this discussion to-night, I have selected processes of a widely differing kind which, I hope, will stimulate a good discussion on this subject. I suppose it is only natural that I should start with electrical devices.

Photo-Electric Relays actuated by a beam of light.

These devices enable machines and other apparatus to be controlled through the medium of a beam of light. The essential element consists of a photo-electric cell, a thermionic amplifier, a sensitive relay, and a small contactor. Light, generally from an electric lamp, is allowed to pass through the window in the relay case to illuminate the cathode of the photo-electric cell.

The device can be operated either by a varying intensity of light, or by interrupted light. In practice this means that if any object be placed between the source of light and the photo-electric cell, the circuit is broken; this is equivalent to opening or closing an electric switch.

To take a simple case; if a photo-electric cell was arranged to operate the door of a restaurant, immediately the waitress walked through the small beam of light, the electrical mechanism would

open the door automatically for her to walk through, and would shut at a predetermined time afterwards.

The operation of mechanism by a beam of light instead of by a solid substance will enable many difficult problems to be solved. For example : (a) Shutting down a machine in the event of breaking delicate fabric ; (b) control of side lay of moving web of paper on bag-making machine ; (c) maintaining constant liquid density according to movement of hydrometers ; (d) lighting lamps when dark, and putting them out when light.

It can be used for counting objects on a conveyor belt, or as a barrier to prevent access to machinery. It has other properties which enable it to select articles according to colour, such as the sorting of coffee beans, or different coloured bottles from a bottle-washing machine.

High Frequency Heating.

Although the high frequency coil is being used for electro-thermic surgery, e.g., in making a bloodless cut so far as the microscopic vessels are concerned, and in producing artificial fever to counteract certain diseases, it should find many applications in mechanical engineering.

Any metallic object which is inside a non-metallic container can be heated to red heat from the inside, without heating the container from the outside. This is particularly useful when melting precious metals, or in melting metal where oxidation must be prevented. A useful application of this is baking of enamel on wire. The wire passes through the high frequency coil and the enamel is heated from the inside by the copper becoming hot, and not from the outside. High frequency heating of steel furnaces is cheaper and much more efficient than other methods, because the metal is heated throughout and not only from the outside.

Thyratron Control for Resistance Welding.

To obtain satisfactory welding with continuous spot or seam welders, it is necessary to supply the current to the electrodes intermittently. On continuous spot welders, the time interval between the impulses of the welding current is now controlled by the welding machine itself, so that the current will be applied at the right period each time the electrodes come together and, to a certain extent, the same remark applies to seam welding. This control of current input may be effected by rotary chokes, which are very detrimental to the power factor. Or it can be done by making and breaking the circuit by contactors, which have a very short useful life, due to the enormous number of operations per minute. The use of the thyratron control unit overcomes all these difficulties, as there are no moving parts.

It consists essentially of two main parts, the timing circuit which controls the duration of each current impulse, and the main valves which control the welding current. The timing device used for seam welders will give impulses from as short as ½ cycle which, at a supply of 50 cycles, equals one-hundredth of a second, and they can be regulated at intervals of ½ cycles upwards. Welding spots can be made close together, or if desired, wide apart by an adjustment of the timer. With a current duration of one-hundredth of a second, the heat is so instantaneous that there is practically no discolouration of the metal, yet a perfect weld is made. This is a great advantage in welding such metal as stainless steel.

Mechanical Devices.

(*a*) *Making of long spiral springs.* Take a piece of square mild steel bar and tap a hole into it, saw the bar through the tapped hole about one-third of the way down, insert a screw, and the projecting screw will act as a former in the tool rest. Turn a piece of mild steel in the chuck of the lathe slightly conical, then twist the spring wire round the cone, press the simple screw former against the wire and start the lathe, the wire will tighten on the cone, and the wire will be made in the form of a spring. With the simple device springs can be made at 800 r.p.m.

(*b*) *Making annular rings in high tensile steel.* A quantity of rings 17 inches outside dia., 11½ inches inside dia. by ⅜ inch thick had to be made in 60 tons tensile steel. These were made in the following manner :

(1) Shear steel into square shape.
(2) Shear corners.
(3) Punch centre hole.
(4) Locate on press on centre hole, and use a punch as a nibbling tool while the operator gradually rotated the blank on the centre pivot. The secret of success of this operation lay in the back support of the nibbling tool.
(5) Locate on outside dia. and nibble the bore.

This job was done on a press at a labour cost of 11½d. per dozen ; the press costing £420.

This is where the production engineer comes in, factories which have large quantities, would spend £3,000 in a blanking press, and complete the rings in one operation, but those who have small quantities have to think a bit harder.

(*c*) *Making scissors out of bent wire.* Here is an exhibit kindly loaned to me by Messrs. Taylor & Challen, Birmingham, showing how scissors can be made of bent wire :

Op. 1.—Bend wire to form.
,, 2.—Weld ring section.
,, 3.—Press to form.
,, 4.—First stripping of flash.
,, 5.—Second stripping of flash.

Other articles could be made cheaply this way.

Everybody nowadays speaks about centralised control. We have centralised control on machine tools, why should not there be centralised control on other items of plant? Take for example an impregnation plant, which consists of a vacuum pump, air compressor, condensers, stirring gear, valves, etc. On most of our recent plant we have arranged for all the operating valves and electrical control gear to be centralised at one convenient place. Even the water for cooling the vacuum pump, air compressor, and condenser, has been brought to one convenient spot. The cooling water, instead of passing into the drains direct, passes via a conical tundish, so that the operator can see that water is actually flowing, and determine its temperature.

Lathes.

I will conclude with a reference to lathes. Seventeen years ago I designed a type of finishing lathe which has features in advance of some of the lathes we see to-day. Perhaps Mr. Field will disagree. We had large quantities of gunmetal components to machine, and it was found that in order to obtain the accuracy from the automatics, we were constantly breaking down the machine for grinding the tools, there being no tungsten carbide tools in those days. It was therefore decided that we should machine these to rough dimensions on the automatics and finish them on high speed finishing lathes. One of the difficulties was that the parts had to be screwed. The usual way is to start with the screw-cutting tool on the right-hand side and feed to the left, and as there was a shoulder on the component it would mean that the machines would have to run at a slow speed so as not to run into the shoulder with the tool. It occurred to me that if we could start the tool at the left and run to the right, the speed of the machine could be considerably increased; in fact the machine was run at first at a speed of 450 r.p.m. and, I believe, later to a speed up to 750 r.p.m. These threads were machined within close tolerances. On other operations the lathes ran at 2,200 r.p.m.

Another important feature was that the chucking of the work had to be done very quickly. Also the components had to be gripped by the collet chuck in the same relative position from a shoulder on the work to the tool.

The machine was started in the morning by the girl operator by means of a hand lever, and the machine was normally running during the day. When the operator depressed the pedal the cone clutch was withdrawn, the collet opened, and the brake automatically stopped the machine ; in a fraction of a second, when she took her foot off the foot pedal, the reverse operations took place automatically. Over 2,000,000 components were made by these machines, and they didn't look any worse for wear. I was told at the time that the machine would not work, in fact, an alternative arrangement was made.

Obviously, with varying diameters, we required something to prevent the work passing inwards, and we inserted a stop in the fixed portion of the collet chuck, relieved in three places to enable the collet to grip the work and pull it against the stop.

MR. E. W. FIELD (Section President) said he had been rather interested in the early part of Mr. Wray's remarks, in his statement that one of his colleagues had taken a standardised article and was eventually going to re-design it and halve the cost. He hoped it was not a turret lathe ! The examples of the utility of the photo-electric cell must appeal to quite a number of those present, particularly any concerned in the lighter operations. He would be interested to know if the amount of power needed to move things off conveyors had any relation to the power of the photo-electric cell ? (MR. WRAY : " No.") Mr. Wray had omitted to state in reference to high frequency heating for metal melting what the frequency was. The figure would be interesting.

MR. WRAY : Depending on a particular problem the frequency may vary between 5,000 and 500,000 cycles.

MR. FIELD : When speaking of the tools used in the manufacture of collapsible tube, Mr. Wray had not told them how they got the blank off the punch ? (MR. WRAY : " By stripping.") The example of centralised shop control had been very interesting, but rather limited in its application. It was a desirable thing to do if one could, particularly on semi-automatic processes taking place on several machines under one operator.

Arising out of that, in one of the leading factories, the temperature control room of the hardening shop was situated two hundred yards away from the shop. They had the temperature control of all processes in the control room, with dials and thermocouples electrically connected to their various instruments.

Finally, the spring rod chuck, which Mr. Wray had described, was the effort on the part of the machine tool maker to save unnecessary time on a job such as that described, and was by no means an unknown method of gripping work or releasing work. As a matter of fact, he remembered having seen in a shop in London a plant for manufacturing aluminium pistons where the spring was used for

holding the piston, and air to relieve the load, gripping being effected by springs.

MR. J. H. GARNETT said he personally had seen the thyratron valve as applied to spot welding and though he did not know very much about it, other than that it was a development made possible as a result of investigations into long distance telegraphy, he could certainly confirm that it had speeded up the process of spot welding very considerably. Machines equipped with the valve operated very quickly and were almost like a high speed sewing machine in their movements.

For his own contribution to the discussion he was going to venture into the chemical field. How many of those present would associate the " Stop me and Buy one " merchant with a production engineering process ? Or did we ever reason why one could buy an ice cream brick, take it home and have it served up, still ice cream, some hours later ? The fact that this could be done, and the reason for the " Stop me and Buy one " merchant definitely emerged as the result of investigations into the question of fruit and food preservation, chemical engineers thus employed having discovered a substance known as dry ice (solidified carbon dioxide). This is produced from what were formerly the waste products of combustion, a feature being that it is capable of inducing terrifically low temperatures, a temperature of 109.6 degrees Fah. below zero being obtained without difficulty. This is much too low a temperature to be comprehended, and for the purpose of comparison one might point out that the lowest recorded atmospheric temperature was 95 degrees Fah. below zero and the estimated mid-winter temperature at the North Pole was only about 42 degrees Fah. below zero. Therefore, dry ice was nearly three times as cold as it is at the North Pole.

Its importance in production engineering is to be found in connection with what are known as shrink fits. With railway wheels it is regular practice to heat the tyre and then drop it over the wheel centre, the tyre on cooling closing in and firmly gripping the wheel centre. But just as expansion can be caused by heat, so can contraction be caused by cold. In view of the development of the linering system in the construction of motor car engines this feature was important. Liners have been standardised by several makers, including the Wolseley Motor Co. Ltd., Leyland Motors, Dennis Motors, Thornycroft, and others, and at least four firms in Birmingham were actively engaged in fitting liners to worn cylinders.

The liners are made from a high grade iron centrifugally cast and were of very thin wall section. They were usually rough bored and ground externally to very fine limits and then pressed hydraulically into the bore which had previously been exactly sized by boring and honing. A pressure of about 3,000 lbs. per square inch was necessary to press the liners home and owing to the thin wall

section trouble through breakage was experienced. The whole of these difficulties were eliminated by using dry ice. This was packing in a refrigerator cabinet and in twenty minutes caused the liners to shrink a matter of 0.006 inch on a diameter of four inches. In this condition the liners could be removed and dropped straight into the cylinder bore. Expansion occurred very quickly resulting in the liners being so firmly held in the bore that they could not be moved at a pressure of 3,000 lbs. per square inch.

To prevent frost forming on the liners through the intense cold they were immersed in a 50 per cent. solution of light dynamo oil and kerosene. This prevented hoar frost and also served as a lubricant when inserting the liners. All told the process appeared to be one that was worthy of close examination, in that, there were many cases where shrink fits were required in which heating of the work was out of the question. By contraction instead of expansion the same results could be obtained with certainty.

Another application of dry ice was in connection with duralumin rivets. These were very extensively used in the aircraft industry and were difficult to handle due to the ageing or self-hardening property of duralumin. The normal practice is to heat treat the rivets and then use them almost immediately, otherwise they hardened and had to be reheat treated before they could be used. By placing heat treated duralumin rivets in a dry ice cabinet they could be kept soft and used at any time up to a period as much as three weeks. Dry ice has also been used in connection with the hardening of certain alloy steels. It has been found that by quenching in a fluid, usually denatured alcohol, lowered in temperature with dry ice, hardening was appreciably affected and in certain cases the treatment prevented discolouration.

Mr. H. C. Armitage said that his contribution would be in the nature of mentioning processes that he would like to see going on, but which were so unusual that he did not suppose they would ever work. He would, however, like to ask one or two questions.

The first thing mentioned by Mr. Wray had been fabrication. Fabrication had arisen at the Institution's meetings many times, and so far as he could see it did not seem to make very much progress. He wanted to know why there was such a thing as a cast-iron casting left in the world, if fabrication was really all that was claimed for it? Why was it that fabrication was not rapidly being adopted? Certainly it was comparatively new still, and an unusual production process, but it had not come into its own yet. Could Mr. Wray tell them what was holding it back? Was it lack of general knowledge on the part of the operator, or was it due to the actual cost of doing it?

Mr. Garnett's remarks on dry ice had been interesting. He would like to know where he could buy a ton of dry ice and what

was its cost? If it was a reasonable price, it might solve a number of cooling problems. For example, it might mean the eventual cutting down of the huge cooling towers that are seen outside all our power stations, and would at the same time be useful for minor cooling problems, such as keeping quenching oil cool when one is continually dipping hot metal into it—one of the worst problems one had to cope with, for the reason that the only effective way of dealing with it up to the present was by water or air or an evaporative system, unless one had thousands of gallons of water at easy access. One was always held up by the small range of temperature between ordinary water and the surrounding atmosphere; in cold weather there was quite a good range, but in hot weather it was very limited, and, worst of all, the hot oil insulated the cooler tubes.

In regard to unusual production processes, he confessed to a lack of knowledge, but he had hoped that someone would tell him how the eyes were put in needles, and how they were brought to that nice, smooth finish, with the grooves right down the needle? There were probably quite a lot of production problems on small parts that the majority of engineers very rarely came across. Only last week he had been to see a machine which was reported to drill holes .0025 inch diameter, but when he got to the machine it appeared that there had been a mistake in the letter—it meant .025 inch, which was fairly ordinary. Even then it was an extremely interesting operation, as even a .025 inch diameter hole could hardly be seen when it was drilled.

Speaking of spot welding, and the thyratron apparatus, it was still in its infancy. He would like to know whether the thickness of the metal governed the speed of the spot welding. Also, whether it was possible, by means of the thyratron apparatus to make a fool-proof spot weld, and in the event of anyone putting a certain amount of insulating medium (say, a piece of paper) between the two pieces to be spot welded, could they still spot weld with it, or could they make the machine reject the job automatically? Perhaps that was where the selenium cell might come in useful, though it was rather doubtful.

Most people had seen selenium cells at work, but from the little he had had to do with them, he had found them very far from being a piece of practical apparatus. There had been one at the Industries Fair, and all one had to do was to put one's hand inside a box and that lit a red lamp. If the hand was put in slowly, it worked, but by putting it in rapidly, one could beat the valve any time.

There was an application of this which had not been mentioned, and that was in connection with speaking films. He believed that in making speaking films, some of the types of apparatus were governed by the photo-electric cell principle, and he understood

it was used in synchronising picture and speech. It seemed to him perhaps the most important industrial development of the cell which had yet come about.

Speaking of the firm with which he was connected a few months previously they had tried an application of the photo-electric cell which so far had not materialised. They had tried to guard their big presses by photo-electric appliance, so that if the man got his arms inside while the press was moving, it would stop the machine, but it had come to nothing. He did not know whether Mr. Wray's firm had yet surmounted that problem? There was a large field in safety work for the photo-electric cell.

It was difficult to define unusual production processes because once a process was developed, it immediately became usual. What was unusual to-day would be perfectly normal to-morrow. The only thing which could be called unusual was something one did oneself and which nobody else knew anything about.

At the present day, one of the biggest advances was the universal spread of knowledge, particularly production knowledge. Before the war, anybody could keep a production process to himself, whereas nowadays we had the opposite. Immediately anything novel was done Mr. Garnett came round and it appeared in *Machinery*, and after that people came to the works to see if they really were doing what Mr. Garnett had said. Incidentally, they enjoyed the same advantage themselves in other works, as a result.

There was an enormous field for pioneer work on practically any job one might pick up; as long as one tried to do it a little bit quicker or better than it had been done before, there was always room for an unusual production process, but after spending a great deal more time and care on it than one had previously done, it became so usual that it was hardly worth calling unusual.

Mr. Wray said that the only reason welding was not making a lot of progress (in some quarters only) was just the same reason why older engineers, brought up on steam driven ships did not want the Diesel, and when they had the Diesel, they did not want electrically-driven ships, because they had no experience of the newer method.

Regarding the practical side of it, in their jig and tool drawing office, nobody thought of a casting, for either jigs and tools, or special machines. He did not think that their young people knew anything at all about castings or had ever drawn one out! It was the same thing in the design office, where other people designed apparatus in cast iron because they knew nothing of welding; if they were to learn something about welding, obviously they would want to design welded structures.

From an engineering standpoint, obviously the cost must be considered. On motors up to a certain size, it was obviously cheaper to make the frame of cast iron, but above that size, practically all

their frames were of mild steel.

In reply to the other question on spot welding, if the thickness of metal was increased, then the time of welding would be longer for the same setting of the machine; another setting would be necessary to reduce the time required.

Regarding automatic control, there is a device on the market which can be adapted to any standard spot welding machine, whereby if the girl depressed the pedal to bring the electrodes together, the current remained on until the weld was made, then the current automatically shut off. The device requires resetting when a different added thickness of metal was being welded.

Regarding the safety problem and the photo-electric cell, it was clear that if one had a beam of light which showed in one plane, and the hands were put in on another plane, above or below, nothing would happen, but if the hand went through, then it would stop the machinery. It had been used considerably for protecting machinery such as Mr. Armitage had described.

MR. ARMITAGE: What is the actual length of time it has to be there to produce the effect?

MR. WRAY: I am not quite sure, but I will obtain this information for you.*

*Regarding the speed of operation of photo-electric cells, raised by Mr. Armitage, Mr. Wray submitted this to the B.T.H. Technical Department concerned, and they replied as follows:

"With regard to the point raised by Mr. Armitage, of the Austin Motor Company, that the speed of operation of photo-electric cells was a limiting factor in their use, the questioner is undoubtedly confusing the speed of operation of the photo-electric cell with that of some photo-electric cell equipments. The photo-emissive cell of which the Mazda PE.7-B is typical, is practically instantaneous in its action. This must be so since the cell is used for sound film reproduction and must respond to light modulated at 10,000 cycles per second with very little decrease in output. For some industrial work the photo-cell response is amplified by a valve and a series of mechanical relays to control a given action, and any slowness in the action of the complete system is due either to the electrical circuit or more usually mechanical relays.

"For many purposes such systems are entirely satisfactory, instantaneous action not being required, but if more rapid action is necessary, it is quite possible to obtain it by using an electronic device known as the thyratron to replace the mechanical relays.

"As an instance of such use, and of the possibility of using photo-electric cells for high speed action, the photo-electric Insetter equipment we market relies upon the photo-electric cell 'seeing' a printed mark $\frac{1}{4}$ inch wide passing before it at a speed of some 1,000 feet per minute, and regulating the machine accordingly."

There is an interesting article on the application of Photo-Electric Cells, for use as a safety device on Presses, by Von H. Alquist, on pages 421 and 422 of the November 1st, 1933, issue of "Werkstatts Technik."

Regarding Infra-Red Sensitive Photo-Electric Cells, Mr. Wray wrote at length to Mr. Chapman in reply to his query, explaining in detail how the photo-electric cell could be made sensitive only to infra-red rays. The reply was too long to be published here.

MR. I. H. WRIGHT spoke in answer to Mr. Armitage's request for information about needle manufacture, and said he had looked into this matter twenty years ago, and the methods that were used then had been used ever since needles were made. Whether there had been any progress in that twenty years he did not know. He had gone round the Singer factory in Kilbowie. The most interesting part was the place where they made needles. Mr. Wright added that he was speaking as an amateur, and did not expect to be cross-examined. The wire from which the needle had to be made was fed through a pair of shears for cutting off to length—the length of two needles—and went through a tube to the cut-off shears. A very simple and ingenious rod feed was used. The pieces of wire, which were now the length of two needles, were ground down to size, and a die stamped the eye and groove and threw out a flash, and its hole was punched through at a later process. The flash was then ground off. Then some frames about 12 inches square, of wood, were used, having a lot of pegs along their edges. Strings smeared with emery were threaded full of needles, hitched on these pegs, and a vibratory motor for some hours smoothed out the eyes.

The needles were ground by hand. The wire was cut off for two needles, and the operator got about ten of them and ground them by holding them on to the grindstone, rolling them by wriggling the fingers. There were efforts being made at that historical period when Mr. Wright was making his survey to do this mechanically by having a hollow-faced emery wheel, mounted on a horizontal spindle, and then a roller covered with rubber. The wires were to be put in at one side and be carried between the roller and grinding wheel, and by the time they had passed through, they would be ground off to something like proper shape. Even when this was used, the point was done by hand.

Speaking about cutting threads very quickly, some years ago he had been associated for a long time with brass finishers' lathes, and that was the way it was always done. To cut a thread up to the shoulder, the lathe spindle was reversed, and the operator brought the chaser down close to the shoulder. He advised any engineer interested in unusual production processes to go round Singers' works, and he recommended the native ingenuity to be found amongst the operators in specialist firms such as this.

MR. WOOLLARD said he would like to amplify what Mr. Wright had said. He had been over Milwards' factory at Redditch a fortnight before, where they have the very latest methods of dealing with needles, and he could say that Mr. Wright's description is now an acomplished fact. They have, however, more recent methods than those, and one new machine he had seen, handled about 250 needles at once ; for grinding the flash off the ends ; first grinding

one side, then turning them over and grinding the other, and finally polishing the ends as well. The drilling of the needles for artificial silk stockings was even more wonderful. They were slotting a hole .005 inch wide for the latch to work in, and drilling a .010 inch hole and tapping it with a tap 250 threads to the inch, for the pin on which the latch hinges. Needle work at Redditch was getting down to a very fine point.

MR. FIELD said he would like to answer one question, or to amplify the answer to a question which Mr. Armitage had put with regard to fabrication. Some eighteen months ago he had been up in the north and been through a rather large fabricating works. Arising out of this visit, it had occurred to him that a lathe bed would be a very interesting experiment. After considering this for some time, they approached a leading firm of engineers who handled this type of work, and submitted to them a design of a normal cast iron bed, approximately 28 inches wide across the shears, standing 28 inches off the floor, and possibly 20 feet long, weighing approximately $2\frac{3}{4}$ to three tons. This was designed and actually made for them, fabricated out of plates of ordinary mild steel; the top shears .5 inch carbon steel $1\frac{1}{2}$ inch thick; and they eventually received the machine and tested it over at least eight or ten months with a really heavy h.p. load (100 to 130 h.p.).

They found that whilst there was really heavy cutting going on, there was an apparent vibration, but which, in no way, showed on the work which came off, and they actually and successfully took a cut .001 inch deep and repeated that cut over two feet of traverse. At the same time they had taken cuts of one inch deep with coarse feeds.

The most interesting part of that was that a short time ago they had decided to move this machine into a more advantageous position. It was lifted in the ordinary way, in the middle with wire slings, to an entirely new foundation, levelled up with fairly accurate levels, and the test department men took it over to test it. They were amazed to see the wonderful results which obtained after moving it, with a headstock weighing $2\frac{1}{2}$ tons hanging on one end and a turret saddle on the other with a direct lift in the middle.

The first test was turning a five inch test bar 27 inches long, which it did within .0002 inch of an inch of parallel.

The next test was boring a 14 inch blank for testing ovality. There was no error as far as their instruments allowed them to go.

This seemed to him to prove that there was rather more behind fabrication than was generally appreciated, and he thought that this machine had had one of the most wonderful tests it was possible for a fabricated structure to have.

To change the subject, and to give one or two more examples of interesting processes, possibly the most interesting one he had

actually seen was the manufacture of lenses for eye-glasses on a really big scale. A factory in Birmingham was producing something in the neighbourhood of 70,000 lenses per eight-hour day. He would suggest to anyone intending to visit that factory that they go in excellent health, and not "the morning after the night before," because it was the most amazing sight one could possibly see.

Another interesting production process which he had seen was the testing of bottles after they had been made. They were made on a rotary machine and came down a conveyor as they were moulded. On one particular day they were making Perrier water bottles at the rate of 24 a minute. They rolled down the conveyor on to a moving track which went through a furnace, and were gradually heated and cooled until they came out at the other end. The method of testing was for a girl to take a bottle from one side and one from the other side and hit them together' If one broke it was rejected ! He suggested that this was not so obvious as it sounded, and advised his hearers to try it for themselves. The girls did this standing over hampers, and if the hampers got full in too short a time, the man further along got into trouble for what he had done the day before ! It *would* be a very unusual process if they could be tested any other way with safety.

Only the previous day he had had the pleasure of going round an establishment where they were making synthetic motor car number plates. Incidentally, this particular material was called Traffolyte, and it was made of a number of mixtures ; practically it was paper, and that paper had to be of various types to suit the various requirements of the actual nameplate. If it was in a situation where it might catch fire at any time, it was made of an asbestos base, but that was expensive, because asbestos was not a material that would lend itself readily to the job. Actually, the ones he saw were made of heavy sections of millboard, soaked and impregnated with various chemicals. On to the surface of these was put a printed sheet, and a sheet, not printed, was put at the back, and then the pile of them was put into a steam heated press and kept there for about twenty minutes. At the end of that time the product was actually burnt—certainly all the chemical was burnt out—and it was almost indestructible. One could scratch them with a penknife without making an actual mark.

Actually this work was being done in the insulation department of an electrical establishment ; owing to the slackness of that particular side of the trade it was on their hands, and it was an excellent way for their research department to experiment with this type of product, but owing to the success of the Traffolyte plates, it seemed as if they would have to build another factory to take care of their insulating materials when trade recovered.

MR. ARMITAGE asked Mr. Field the original thickness of the cast iron bed which the fabricated one replaced.

MR. FIELD replied that it was about $\frac{3}{4}$ inch to $\frac{7}{8}$ inch. There had been no attempt to say that steel was three times stronger.

MR. ARMITAGE suggested that the failure of fabrication to make progress was due to the fact that cast iron could not yet be welded to steel. He described a process which had come to his notice which claimed to give cutting tools, crank shafts and parts of that kind a life twice as long as they ordinarily had, the process being to put them into a " little black box " for a certain time, no indication being given of what the process really consisted. He asked if any members had tried this process ? His firm had tried it on a number of tools, and could not say that they got any more out of them as a result. It was due, perhaps, to their lack of faith.

MR. WOOLLARD replying to Mr. Armitage's query, said that he happened to be operating the described process, and could assure him that the results justified his existence, at any rate. It was a secret process, and he could therefore say no more, but it had been very much developed, and in view of the fact that work was coming to them from all over the country, and repeat orders, and that people were not in business nowadays for philanthropic motives, they were justified in claiming that it was a success.

MR. ARMITAGE : Is it the Macrome Process ?

MR. WOOLTARD : Yes. The Macrome Steel Process. He could not tell them how it was done. There was no difference in the appearance of the tools after being treated. They had tried micrograhs at two thousand diameters without success but had found that they could get good results at about 150 diameters magnification. They had thought that it would show up in the larger magnification, but found that this was not so. It was definitely a new thing, two or three years ago, and had taken a lot of experimental work to get down to standardising to suit various steels. For each steel it was a different treatment, which had to be varied according to the analysis. It was rather a disadvantage that they were dependent on the uniformity of the steel. It was an electrical heat treatment, and if it were patented everybody could use it in their own works : there was nothing to show that it was being done owing to there being no alteration in the appearance of the tools after treatment.

MR. W. A. J. CHAPMAN referred to researches carried out by Mr. E. G. Herbert in connection with magnetic hardening a few years ago. He had worked on high speed steel, and the speaker thought that the work was still being carried on. As many of them would know, at various temperatures, steel had a minimum work-hardening capacity, and at other temperatures, a maximum work-hardening capacity. Furthermore, if the steel were caused to rotate in a magnetic field at certain temperatures, it was thought that a

redistribution of molecular structure took place producing an increase in hardness.

In connection with this, Herbert has demonstrated that steel can be hardened considerably above the hardness which was given by the usual heating and quenching in oil. He had published one or two reports on his work. Probably the "secret" process might be connected with this? It was a question which Mr. Garnett could answer better. Mr. Chapman further spoke about Stelliting, and asked for information as to whether the process was used very much at the present time. He had not the opportunities that some other members had of getting about, and would like to know, as he had been interested in it in its early days. He wondered whether any work had been done with photo-electric cells which were sensitive to infra-red rays, because there are, on the market, photographic plates which were sensitive to them? He could see great possibilities in getting photo-electric cells sensitive to the infra-red part of the spectrum. One application of it might be to institute control in hardening and heat-treatment where the object was below red heat.

Mr. Garnett said that dry ice was obtained from the I.C.I. Regarding the use of dry ice for the purpose which Mr. Armitage had mentioned, he was of the opinion that it would be rather too costly for use on such a large scale, but in the case of the operation he had referred to, the cost would be almost negligible because of the small amount required for bringing cast iron from its normal state down to the lower temperature required.

Mr. Fenton described by way of an example of an unusual production process, the cutting of a steel gear 12 inches diameter 14 feet face, 2 inches pitch on a planing machine. When he was abroad before the war he had an inquiry to cut a gear of these dimensions, and although it could be cast and turned there were no facilities for cutting it. They achieved this by cutting it on a planing machine, mounting the turned gear on the cross rail of the planer with a smaller gear having the same number of teeth at the back for indexing purposes. A lathe screw and nut were coupled up to the table of the planer and driven through a worm reducing gear by a reversing electric motor, another worm reducing gear was mounted on the table of the planer, also driven by an electric motor, and the cutter mounted on an extension of the wormshaft, two cuts were taken, the first with a gashing cutter, and the second with a form gear cutter. A gear was cut roughing and finishing in 120 hours, and ran very well when mounted.

Out in the Colonies, many things which at home are quite simple, become unusual production processes. He remembered a case of an oil engine which had been used on a pumping plant and was converted to drive the electric lighting plant, and was not giving very good results. It was decided that the trouble was due to the fly-

wheel not being heavy enough. As a new flywheel was out of the question, some large steel plates were bolted each side of the flywheel, trued up with the engine running as slowly as possible, and five tons of fencing wire was then wound on to the rim. This proved a most satisfactory solution of the trouble.

MR. B. T. WARE spoke about a process which was, in his opinion, a rather unusual process at the time, but which had now been superseded in favour of drawing. This was in the manufacture of filaments for electric lamps, where by the medium of an hydraulic press, a special paste was extruded through a diamond die on to paper placed on a table, which was then reciprocated backwards and forwards an amount equal to the length of the filament required, the table at the same time being fed sideways ; the result being that the filament was formed to the right shape for ultimately being hung on to the supporting wires fixed in the stem of the lamp. The whole thing was then baked in an oven and the protecting casing burnt off, leaving it ready for placing in the bulb for final operations. The process was interesting because the heat for burning off the protecting fluid after extrusion was so vital that a temperature of plus or minus 15 degrees was the limit that could be used with safety. If this was exceeded it was either too brittle to handle or too soft to be of use.

MR. FIELD mentioned the present growth of metallisation, the process he had in mind being the spraying of metals in wire form by a combination of coal gas, oxygen, and compressed air, which actually deposited various finishes on to a much more common base. The process as he had seen it up to the present was largely used in the aircraft industry, particularly on seaplanes, as an anti-rust finish. It certainly prevented oxidation from the seawater, but increased the weight rather alarmingly, and could only be used on the heavy classes of seaplanes. It was not quite suitable for use on light planes, but it had many possibilities apart from that. The amazing part about it was that molten metal could be sprayed on to one's hand without burning it, as compressed air cooled it as it left the gun.